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COMBINED SEWER OVERFLOW SEMINAR PAPERS

A compilation of technical papers and discussions presented at three seminars in New York State given jointly by the U. S. Environmental Protection Agency and New York State Department of Environmental Conservation.

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FORWARD

The U.S. Environmental Protection Agency in conjunction with the New York State Department of Environmental Conservation conducted three one-day seminars on the problem of wet-weather flow pollution abatement. Many facets of the problem were considered including a brief overview of its magnitude and what the federal government is doing to manage and control this source of pollution. Various management, control and treatment techniques were described and the most up-to-date information on design and economics was presented. The audiience consisted of consulting and municipal engineers from all areas of New York State.

It is hoped that these seminars and this compilation of papers will help solve community problems or at least stimulate new ideas as to how storm and combined sewer overflow pollution abatement might be approached.

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SECTION I

STORMFLOW POLLUTION CONTROL IN THE U. S.

by

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I. PREFACE

In an effort to introduce this seminar and tie the various discussions you'll be hearing today together, I thought it would be appropriate to discuss the problem of stormwater discharges and combined sewer overflows from the Federal Government's involvement.

The nation-wide significance of pollution caused by storm generated discharges was first identified in a U.S. Public Health Service report published in 1964. Congress, in recognizing this problem, authorized funds under the FWPC Act of 1965 for the research, development and demonstration of techniques for controlling this source of pollution. Further authorization has been provided by the 1972 Amendments to the Act.

Hence, the Storm and Combined Sewer Overflow Pollution Control Program was originated and the problem of wet-weather flow pollution was classified into three categories:

1. Combined Sewer Overflows
2. Stormwater Discharges
3. Non-Sewered Runoff

To date over 116 grants and contracts totalling over $82,000,000 have been awarded , the Federal Government's share being in the neighborhood of $40,000,000 or 47.5%.

II. INTRODUCTION

The earliest sewers were built for the collection and disposal of stormwaters, and for convenience emptied into the nearest watercourse. In later years, house sewage was discharged into these large storm drains, automatically converting them into "combined" sewers. Subsequently, combined sewers came into widespread use in communities because they represented a lower investment than the construction of separate storm and sanitary sewers. (Fig. 1)

When the problem of pollution caused by sanitary or dry-weather discharges became recognized, the engineer was confronted with how to best separate the wet from the dry-weather flows to enable proper treatment of the sanitary sewage portion. This was overcome by designing overflow structures at selected points in the sewerage system, so that combined sewage flows greater than a predetermined multiple of mean dry-weather flow were discharged directly into the receiving stream. The diversion points were usually chosen close to the receiving water for economy, and new sewers were installed for intercepting and conveying the dry-weather flows to the sewage works for treatment.

These overflow or relief points may also be integral to separate sanitary systems. Initially, nominal allowances were made for infiltration and with pipe age this became more of a problem. Unauthorized connections compounded the problem, and reliefs in the "so called" separate sanitary system were used as an immediate and low cost solution. Studies conducted for the USEPA found that separate systems, with excessive infiltration and other inflows, act essentially as combined sewer systems.

III. COMBINED SEWER OVERFLOW PROBLEMS

The basic difficulty with combined and "nominal" sanitary sewers involves their "built-in" inefficiencies, i.e., their overflow points.

Untreated overflows from combined sewers, particularly during wet-

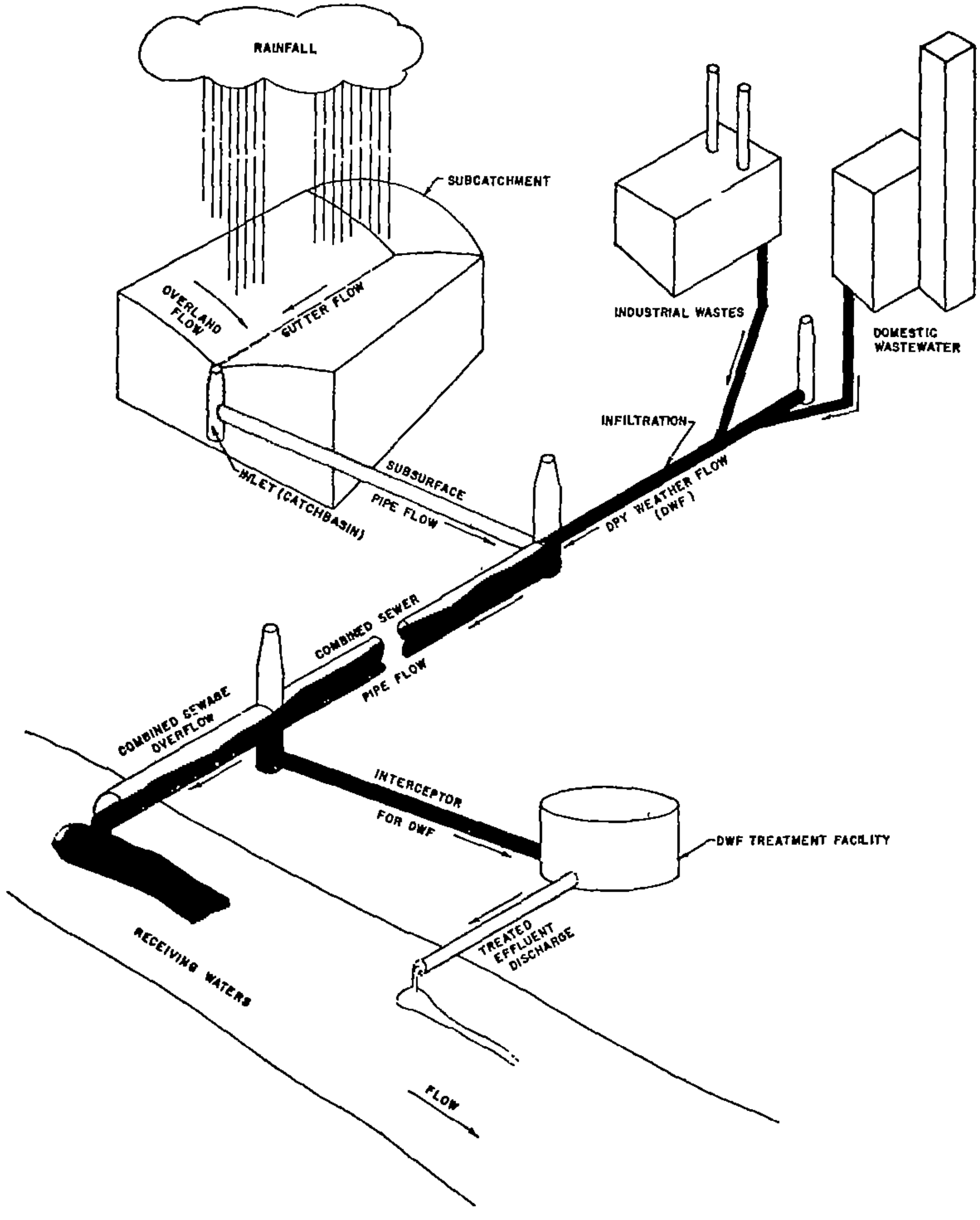


Figure 1. SCHEMATIC SYSTEM DRAWING RAINFALL THROUGH OVERFLOW

weather, has proven to be a substantial pollution source in terms of impact upon receiving stream water quality--even though the percentage of sanitary sewage lost from the system by overflow is small, that is, in the order of 3 to 5 percent.

Pollution problems stemming from combined sewer overflows are widely distributed through the United States; the Northeast, Mid-west, and Far-West being the principal areas of concentration. In a nation-wide survey performed by the APWA it was found that there are over 3,000,000 acres of combined sewer drainage area contained in more than 1,300 municipalities with a population of 54 million served by some 55,000 miles of combined sewers. Of 641 jurisdictions surveyed,

- 493 reported some 14,200 combined sewer overflow points,
- 340 reported infiltration problems during wet-weather and
- 96 indicated combined sewer overflows during dry-weather.

The magnitude of the overflow problem was exemplified by a 2-year study conducted on a 229 acre combined sewer watershed in Northhampton, England. This study showed that the cumulative yearly biochemical oxygen demand (BOD) load in the combined sewer overflows nearly equaled the BOD load contained in the effluent of the local secondary treatment plant. Suspended solids within the overflows were three times the load contributed by the treatment works effluent.

The relatively poor flow characteristics of combined sewers during dry-weather when sanitary wastes alone are carried, encourages settling and build-up of solids in the lines until a surge of flow caused by a rainstorm purges the system. Studies in Buffalo, New York have shown that 20 to 30 percent of the annual collection of domestic sewage solids are settled and eventually discharged during storms. As a result, a large residual sanitary pollution load, over and above that normally carried is discharged over a relatively short interval of time, oftentimes resulting in what is known as a "first flush" phenomenon. This can produce shock loadings detrimental to receiving water life.

Aside from the raw domestic and industrial sewage carried in the overflow, non-sanitary urban runoff in itself is a significant contributor to the overflow pollution load. As the storm runoff drains from urban land areas, it picks up accumulated debris, animal droppings, eroded soil, tire and vehicular exhaust residue, air pollution fallout, heavy metals, deicing compounds, pesticides and PCB's, fertilizers and other chemical additives, decayed vegetation, hazardous material spills, together with many other known and unknown pollutants. A study on a 1,067 acre drainage basin in Durham, North Carolina has shown that the annual BOD contribution attributable to surface wash from storms is approximately equal to that contribution of the secondary treated sanitary effluent and the total organic matter exhibited by chemical oxygen demand was estimated to exceed the amount in the raw sanitary sewage from a residential area of the same size.

It is important to note that there is no apt description of "typical" combined sewage or stormwater runoff characteristics due to the variable nature of the rainfall-runoff patterns. Figure 2 illustrates some general concentration ranges of the wastewater constituents listed. The major characteristic, i.e., qualitative variability, is shown by these data. Quality may range from superstrong sanitary sewage during the "first flush" to very diluted sewage later in the storm. The composition is dependent on a number of factors, including: length of antecedent dry weather, local climatic conditions, condition of the sewerage system and the nature of the drainage area.

FIGURE 2

CHARACTERISTICS OF COMBINED SEWER OVERFLOWS
(SELECTED DATA)

BOD_5	-	30	TO	600	MG/L
TSS	-	20	TO	1,700	MG/L
TOT. SOL.	-	150	TO	2,300	MG/L
VOL. TOT. SOL.	-	15	TO	820	MG/L
pH	-	4.9	TO	8.7	
SETTL. SOL.	-	2	TO	1,550	ML/L
ORG. N	-	1.5	TO	33.1	MG/L
NH_3N	-	0.1	TO	12.5	MG/L
SOL. PO_4	-	0.1	TO	6.2	MG/L
TOT. COLI.	-	20,000	TO	$90x10^6$/100 ML	
FEC. COLI.	-	20,000	TO	$17x10^6$/100 ML	
FEC. STREP.	-	20,000	TO	$2x10^6$/100 ML	

As mentioned, urban stormwater in itself is a significant contributor to the problem since it picks up a variety of known and unknown pollutants as it drains from urban land area. Figure 3 illustrates some selective data on urban stormwater characteristics. As noted, the extremely high chlorides concentrations have been attributed to deicing salts. Our program has done some work in this area resulting in the following conclusions:

1. Highway salts can cause injury and damage across a wide environmental spectrum.
2. Practically all highway authorities in the U.S. believe that ice and snow must be removed quickly from roads and highways and that "bare pavement" conditions are necessary, often resulting in excessive salt application.
3. Salt storage sites are persistent and frequent sources of ground and surface water contamination and vegetation damage.
4. The special additives, e.g., chromates and cyanides, found in road deicers provoke great concern because of their severe latent toxic properties and other potential side effects.
5. A sufficient number of incidents and detailed studies have been described to show adverse impact of deicing salts to water supplies and receiving waters.
6. In less severe cases as salt intrusion into public water supplies--salt free patients have been cautioned to change their potable water source.
7. Deicing salts are found in high concentrations in highway runoff.
8. Surveillance data is needed to clearly define the many influences of deicing salts upon the environment.
9. The majority of in-depth studies support the finding that deicing salts are a major factor in vehicular corrosion and roadway damage. The literature also indicates that rust

FIGURE 3

CHARACTERISTICS OF URBAN STORMWATER
(SELECTED DATA)

BOD_5	-	1	TO	>700	MG/L
COD	-	5	TO	3,100	MG/L
TSS	-	2	TO	11,300	MG/L
TOT. SOL.	-	450	TO	14,600	MG/L
VOL. TOT. SOL.	-	12	TO	1,600	MG/L
SETTL. SOL.	-	0.5	TO	5,400	ML/L
ORG. N	-	0.1	TO	16	MG/L
NH_3N	-	0.1	TO	2.5	MG/L
SOL. PO_4	-	0.1	TO	10	MG/L
TOT. PO_4	-	0.1	TO	125	MG/L
CHLORIDES	-	2	TO	25,000	MG/L*
OILS	-	0	TO	110	MG/L
PHENOLS	-	0	TO	0.2	MG/L
LEAD	-	0	TO	1.9	MG/L
TOT. COLI.	-	200	TO	146×10^6/100	ML
FEC. COLI.	-	55	TO	112×10^6/100	ML
FEC. STREP.	-	200	TO	1.2×10^6/100	ML

*WITH HIGHWAY DEICING

inhibiting additives do not produce results to justify their continued use. It is further noted that deicers may attack and cause damage to telephone cables, water distribution lines and other utilities adjacent to streets and highways.

10. There is little doubt that road deicers can disturb a healthy balance in soils, trees and other vegetation comprising the roadside environment.

Sewer Separation

When considering combined sewer overflow problems, first attention is generally given to the construction of separate sanitary and storm sewer systems. In contrast, the 1964 PHS study stipulated that alternative solutions be investigated to determine if means other than sewer separation could be found at lower cost.

The previously mentioned APWA study of combined sewer problems indicated that if all communities with combined sewers in this country were to effect sewer separation, they would face an expenditure of approximately 85 billion dollars at today's cost. Of this amount New York State's share would roughly come to $18 billion, the highest figure for any state in the nation. It was further estimated that the use of alternate measures could reduce the national figure to about 25-30 billion dollars.

It is again emphasized that urban stormwater runoff itself can be a significant source of stream pollution. Sewer separation would not cope with this pollution load. An EPA study revealed that if separation were used, the reduction in wet-weather pollution would be only 50 percent. The other 50 percent would remain in the untreated urban storm runoff.

IV. CORRECTIVE METHODS

Program research, development and demonstration projects have provided significant results, and have illustrated that sewer separation in most cases is not the logical course of action. We have categorized three basic approaches other than separation: control, treatment and combinations of the two.

Control

Control of combined sewer overflows can be obtained by reduction or equalization of peak stormwater flows, increasing the effective capacity of the sewerage system, minimizing infiltration and by source prevention techniques.

For existing system control, the operator can attempt to maximize wastewater treatment at the sanitary plant during wet-weather by trying to contain as much flow or treat as much sewage as possible during a storm flow occurrence. This would serve to reduce wet-weather by-passing which at the beginning of storm flow can have a high pollutant concentration, as previously described. It is recognized this extra plant burden may decrease treatment efficiencies somewhat, and create added sludge or solids handling problems; however, these practices for only short periods during storm flows are well worth the effort. If the operator determines that hydraulic loading will cause a serious upset of a unit process then primary treatment plus disinfection should be considered as a minimum measure.

In Detroit, where the prevailing direction of storms is known, the operator receives advanced information on storms from a remotely stationed rain gauge. The treatment plant pumping is increased, thus lowering the surcharged interceptor gradient, allowing for greater interceptor storage capacity and conveyance. This practice has enabled the city to entirely contain and treat many intense spot storms plus many scattered city-wide rains.

The operator should also concern himself with improved regulator inspection and maintenance, and preventive schedules to minimize the occurrence of overflows. Overflows during dry as well as wet-weather due to malfunctioning devices and clogged orifices can thus be alleviated. Tide gate conditions allowing backwater intrusion can be corrected, and diversion structure settings can be raised to obtain more interceptor carrying capacity.

Municipalities can also control combined sewer overflows without large and costly modifications by concerning themselves with infiltration and extraneous inflow. Excess flow caused by infiltration is a major thief of capacity that would otherwise be available to transport wastewater and can thereby affect proper operation of sewerage systems and, consequently, the quality of streams. Other adverse impacts caused by infiltration include: (a) surcharging and back-flooding into streets and private areas and need for relief sewers ahead of schedule; (b) surcharging of treatment plants and pumping stations, causing flow by-passing, decrease in treatment efficiency, and higher treatment costs; and (c) diversion of raw wastewater and greater incidence and duration of overflows. The APWA has reported that infiltration was a pronounced problem during dry weather in 14 percent of communities surveyed and in 53 percent of the communities during wet weather. The APWA also indicates that other sources of extraneous inflow compounding the problem include roof leaders; depressed manholes covers; cellar, foundation, and yard drains; air conditioning and industrial cooling waters; and other connections.

Control of infiltration should first take place during sewer pipe installation. Better construction materials and proper installation techniques are necessary. The new methods of sewer·sealing and lining should be fully evaluated before major rehabilitation or replacement is undertaken.

Infiltration surveys should be undertaken when extraneous inflows are suspected. Such surveys may use television and other visual pipeline inspection, smoke tests, air and water pressure tests, and various flow techniques. Undue deposits, partial blockages and cave-ins causing premature surcharging and dry- and wet-weather overflows (usually in older sewer systems) will also be pin-pointed for subsequent corrective action.

Building connections to street sewers are a major source of infiltration. As much as 70 to 80 percent of the infiltration load can occur in these lines. Accordingly, the aforementioned infiltration control practices should be strictly followed here.

Before a municipality considers removing extraneous inflows, the following basic factors should be considered:

1. Determination of what a "clean" or unpolluted inflow really is. For instance, subsurface drainage may be contaminated leachate or contain toxic material washed from basement floors.
2. Sewer septicity and odor conditions that may arise because of lowered flow from the elimination of long-standing inflow sources.
3. Effect on the public of any sudden decision to eliminate inflow sources and the associated problems of enforcement.
4. The strong possibility that communities will be forced to treat separate urban runoff sometime in the future indicates that the reconnection of certain so-called "clean" waters from sanitary to storm drains may be done in vain.

Studies have indicated that it may be cheaper to remove solids from the street surfaces by sweeping than by eliminating them via the sewer system. One set of figures showed that street sweeping costs $24 to $30/ton of solids removed as compared to $60 to $70/ton of solids removed via the sewerage system. What may be even more important is that the wet-weather overflow polluting potential of these solids is eliminated by the urban surface removal practice.

Aside from abating the usual contaminants, a particular advantage of effectively removing the dust and dirt fractions prior to sewer entry would come from the reduction of major amounts of the more exotic pollutants which include heavy metals (lead, zinc, cadmium, mercury, copper, chromium), pesticides and PCB's, and nutrients that commonly adhere to the surfaces of solids. Because of the potential land and groundwater contamination, care should be given to the solids disposal site selection and the fate and effects of these pollutants. At this juncture it is appropriate to mention that greater efforts should be applied in the area of non-routine stormwater constituents. Their impacts and abatement measures must be further researched, whether they be by surface "housekeeping" at the source or treatment of the storm flow itself.

It is recommended that the newer and more promising street cleaning equipment such as vacuum sweepers, air brooms and wet scrubbers be further evaluated and employed as opposed to conventional sweeping and flushing methods. The newer devices offer benefits in picking up the dust and dirt particles rather than redistributing them for aesthetic purposes as the conventional devices do.

Certain land use, zoning, and construction site erosion control practices are other ways of alleviating the solids burden to the receiving streams or treatment plants by surface source prevention.

Cleansing of catch basins, sewer lines, wet wells and other appurtenances by flushing or dry mechanical means may reduce solid loadings in wet-weather discharges and alleviate premature overflows during dry or wet periods due to partial or complete sewer obstructions. But here we must weigh the benefits of system cleaning against "closing the loop" by the installation of wet-weather flow control and/or treatment facilities.

It is emphasized that before a community considers the establishment or continuation of the household garbage grinding practice, it must be realized that increased solids deposition in both combined and sanitary sewer lines will occur at times of low flow during dry weather which will be scoured out by the high storm flow conditions. As a result, the overflows will create more severe stream impacts. The jurisdiction's plans regarding future overflow control and treatment will be an important consideration since again the "loop" will be closed.

If there is insufficient carrying capacity in the sewer lines, polymer addition may serve to measurably reduce fluid friction. Research has shown that polymeric injection can increase flow capacity as much as 2.4 times at a constant head. This method can be used as a measure to correct troublesome pollution-causing conditions such as localized flooding and excessive overflows. Preliminary cost comparisons have shown this procedure to be feasible.

Advanced Control Systems

In this segment of the talk, some of the newer and more advanced technology being developed by our Program will be described.

Flow Regulation

Several methods have been used to reduce operation problems associated with the conventional regulator devices. Cincinnati utilizes telemetered monitoring to detect unusual or improper dry-weather overflows. More sophisticated approaches are being applied by the Minneapolis-St. Paul Sanitary District and the Cities of Detroit, and Seattle. All three jurisdictions are making use of unused storage capacity within the existing sewerage system for the purpose of reducing the frequency and volumes of overflows. For instance, in the period from 1969 to 1970, Minneapolis was able to reduce overflow occurrences by 55% and the volume of overflow by 85%. The general approach comprises remote monitoring of rainfall, flow levels, and sometimes quality, at selected locations in the network, together with a centrally computerized control console for positive regulation of the overflow structures. Figure 4 depicts the computer console and strategy room in Seattle, and is a preview of what the operator in 1980 may be contending with.

New types of regulators such as positive control gates and inflated rubberized-fabric dams (Figure 5) have been demonstrated successfully. Another unique overflow device which has been constructed for full-scale demonstration utilizes fluidic technology; and requires no moving parts or external power since operation is entirely dependent upon motion of the wastewater. Improved regulator capability and reduced operation and maintenance costs are anticipated. Additional improvement in regulators is now in progress.

Storage

Storage offers direct control by containing the wastewaters produced during wet-weather periods. The use of storage facilities for controlling combined sewer overflows has been convincingly demonstrated. The general procedure involves the return of re-

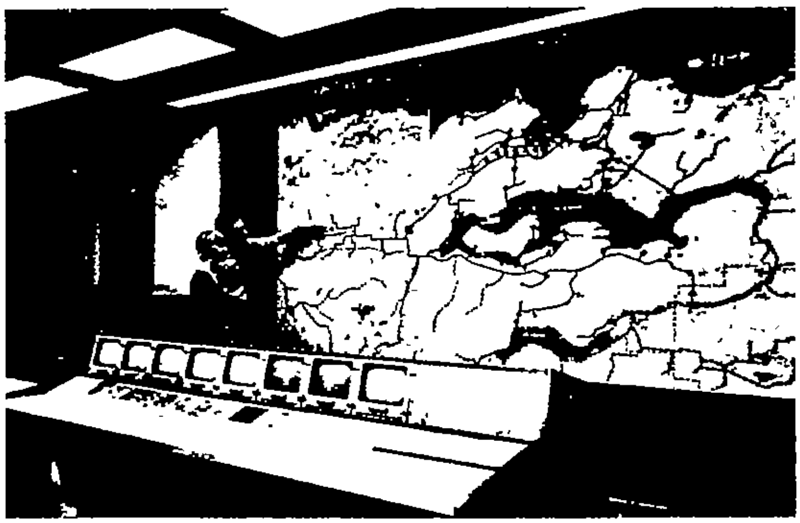


Figure 4. Computer console for augmented flow control system, Seattle, Washington.

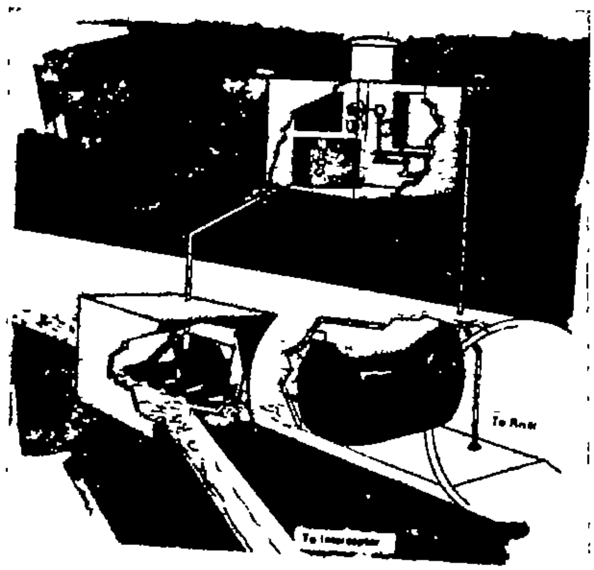


Figure 5. Inflatable Control Gate System

tained overflows to the conventional treatment works for subsequent treatment during low flow, dry-weather periods.

Concrete holding tanks are the most commonly used type of storage facility. The storm stand-by tanks at Columbus, Ohio, shown in Figure 6, constructed as early as 1932, were recently modernized by installation of sludge collection and automatic flow control equipment. The City of Boston has commenced operation of overflow holding tanks designed to provide 10-minute settling plus chlorination for treating excess overflows of 233 million gallons per day. New York City and Milwaukee have similar facilities in operation. The New York City plant has four storage tanks which have a combined capacity of 9.7 million gallons. Intercepted storm flow is stored, degritted, and pumped, along with the sludge back to a nearby Municipal Treatment Plant. Excessive overflows receive treatment by sedimentation through the tank and are chlorinated and discharged. The objective of the facility is to reduce coliform and solids contamination of Jamaica Bay.

Chippewa Falls, Wisconsin has constructed an asphalt-lined basin providing storage for up to 3.5 million gallons of overflow. (Figure 7) During the 1969 - 1970 evaluation period, 50 river discharges out of 62 storm overflows were eliminated.

Two basic problems encountered by conventionally-designed storage facilities in urban areas are land cost and availability, and adverse aesthetic impacts. In this regard, we are seeking new concepts. A major demonstration in Chicago involves the new concept of "deep tunnels". The cost of the Metropolitan Chicago tunnel storage system is estimated at over one billion dollars as contrasted to over four billion for sewer separation. Additional benefits of tunnel (or in-sewer) storage are a result of coverage of an expanded area or length. Thus, storage is more readily avail-

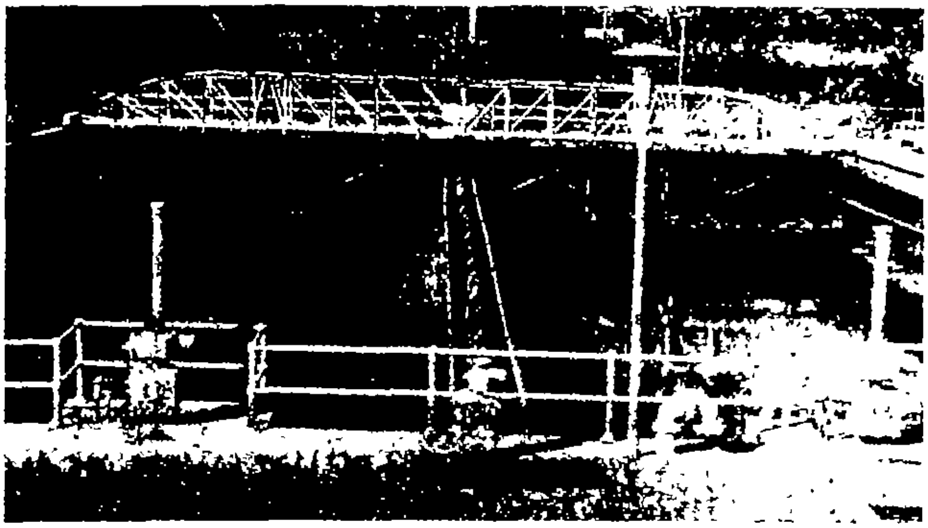


Figure 6. Storm Stand-by tank with upper portion of sludge collection mechanism visible, Columbus, Ohio.

Figure 7. Asphalt-lined basin providing storage for up to 3.5 MG, Chippewa Falls, Wisconsin.

able to remote areas, hydrographs may be smoothed or reduced for treatment facility design because intense storms often are quite localized, and overflows greater than storage capacity can be selectively and automatically discharged to the most suitable stream locations. Another subsurface storage idea to be demonstrated in Lancaster, Pa., is the underground "silo". The use of a 50-foot diameter, 100-foot deep silo could afford over 1 million gallons of storage. The preliminary design is shown in Figure 8.

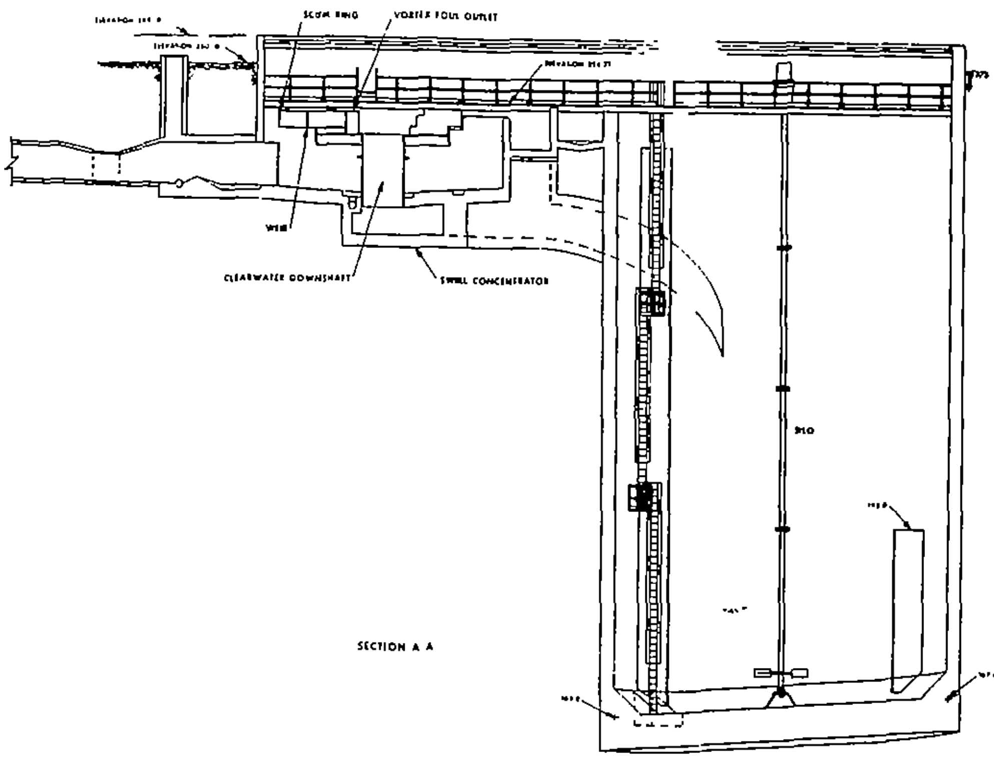
Other designs requiring little or no urban land include offshore storage and the use of natural underground formations. Two demonstration projects have evaluated the use of flexible neoprene-coated nylon fabric material as underwater containers, for the temporary storage of combined sewer overflows. Figure 9 presents a drawing of such an installation.

The engineer and operator will be interested in the sludge-handling aspects of temporary storage. Two possibilities are the re-suspension of solids by agitators and settling prior to pump-back. Re-suspension can provide easier draw-off and is being evaluated. However, if sludge is settled, on-site sludge disposal in lieu of solids pumped back in stored flow should be considered.

Design criteria should be based on the pollution abatement results expected. For example, Milwaukee used a mathematical model to determine size and projected efficiency of its holding tanks.

Wherever possible, design of full-scale facilities should consider the total environmental impact, including aesthetics. Figure 10 is a conceptual drawing showing an off-shore site in Lake Erie at Cleveland, Ohio

A concept worthy of note, which was successfully demonstrated in



Preliminary Drawing - Elevation View of System, Lancaster, Pa.

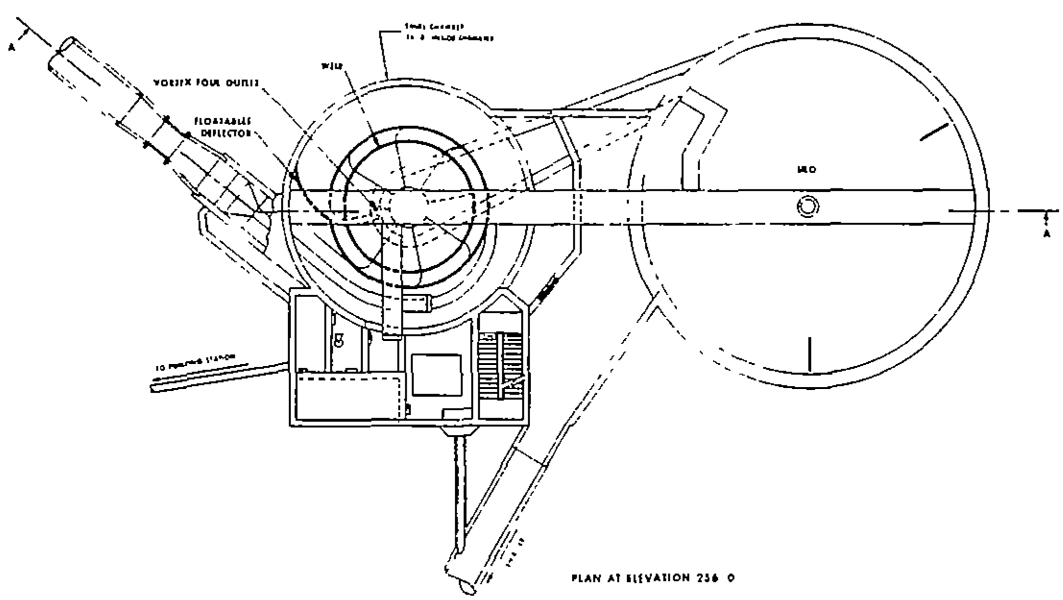
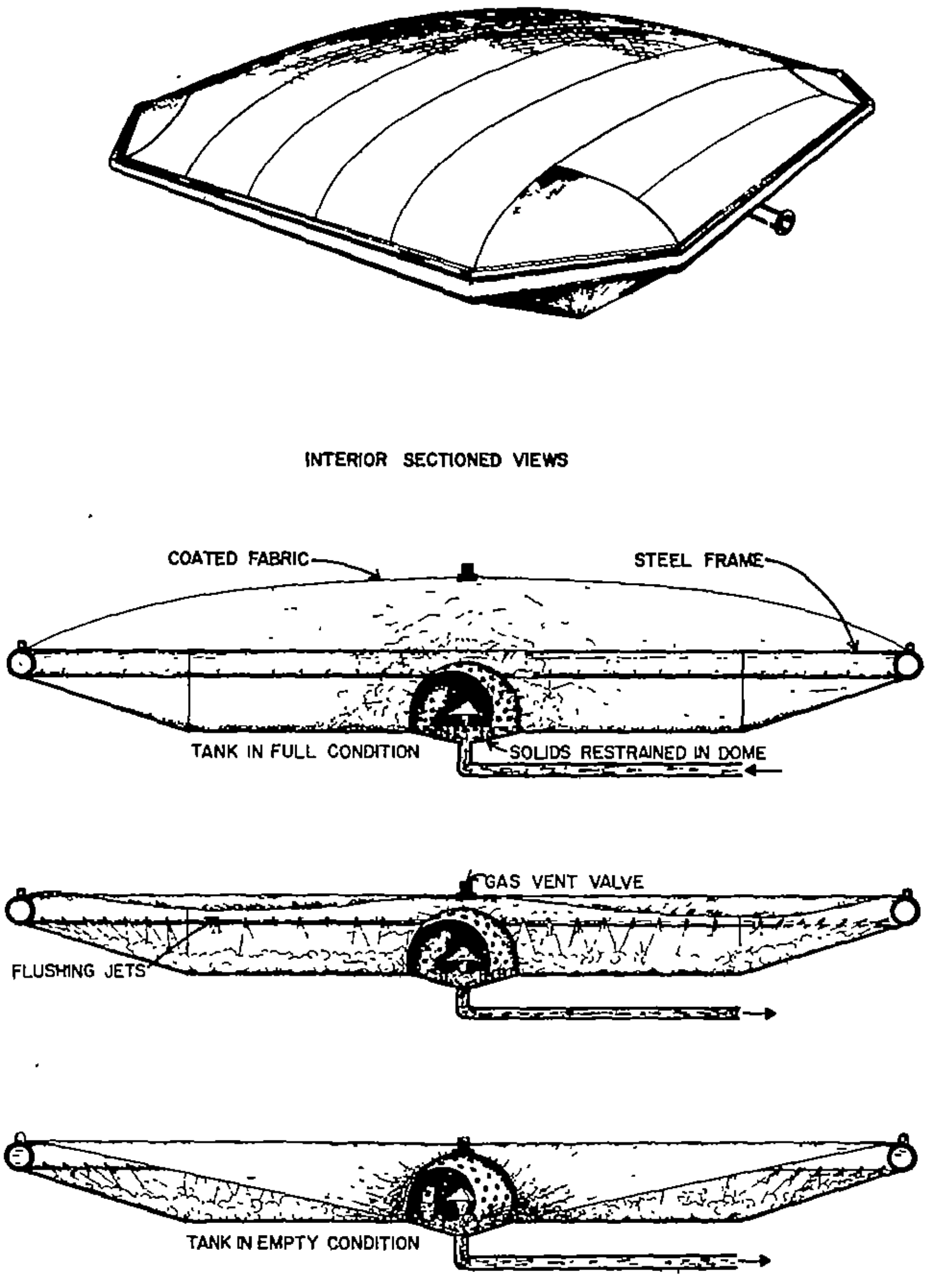


Figure 8. Preliminary Drawing - Plan View of System, Lancaster, Pa.

FIGURE 9

UNDERWATER TANK



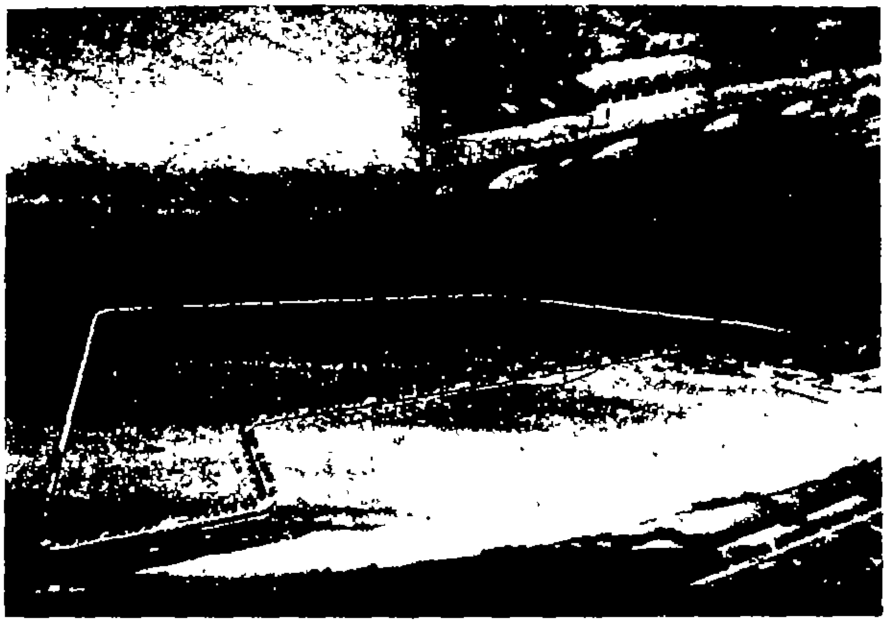


Figure 10. Conceptual design of combined sewage retention-stabilization basin, Cleveland, Ohio

London, England and Decatur, Illinois, is the conversion of existing or abandoned sanitary treatment units, in this case sedimentation tanks, to storm holding facilities as part of a plant expansion. Also, plans have been proposed to use an abandoned trickling filter as a storage tank for stormwater infiltration.

Porous Pavement

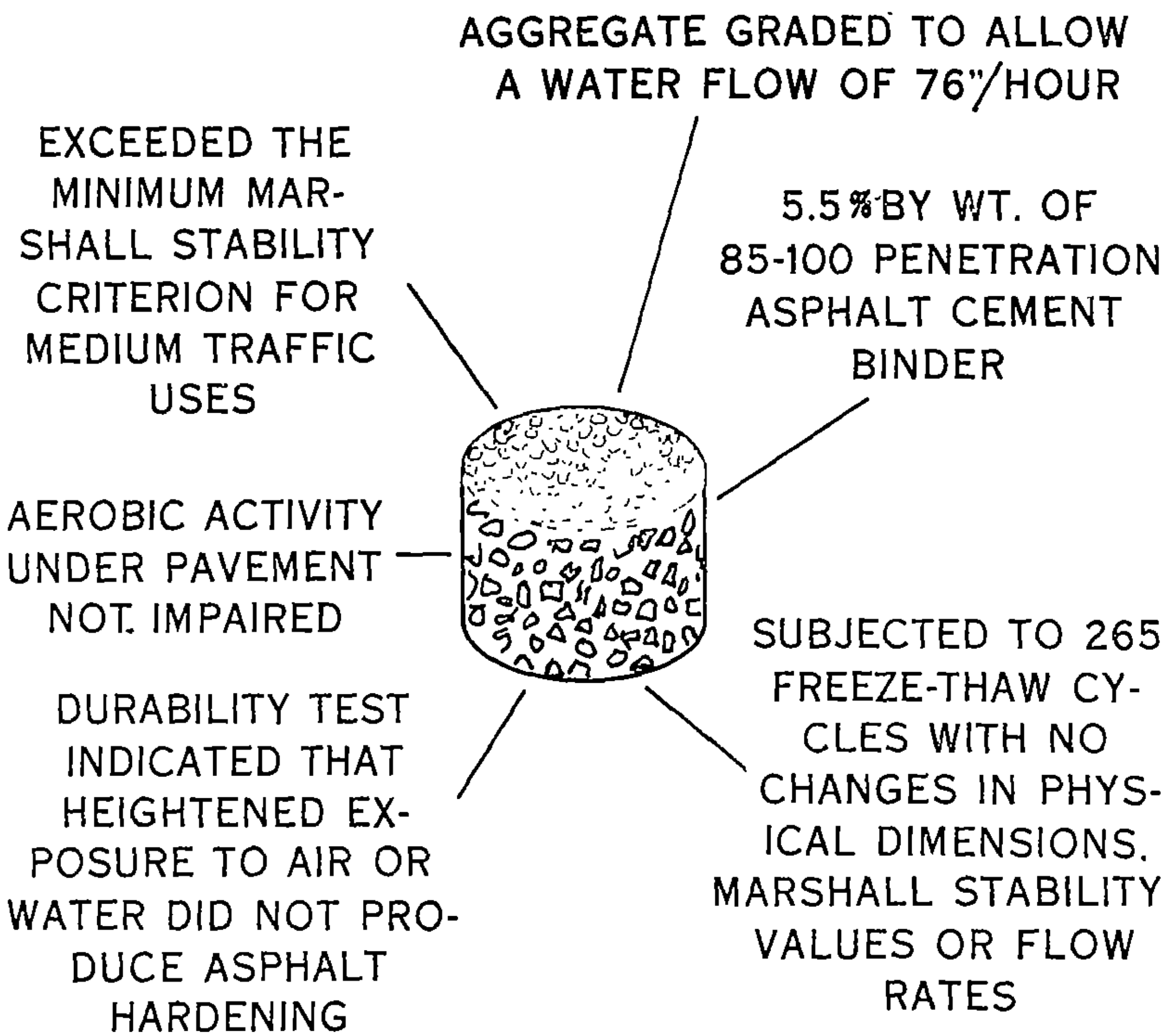
Another feasible method to attenuate flows is the installation of porous pavement. This pavement is made of asphaltic-concrete and has been developed for an ability to allow 60 or more inches per hour of rainfall to permeate through its depth (Figure 11). If used for major highway, street, and parking lot paving projects, it would have the potential for reducing capacity and associated costs for both sewer and wet-weather flow treatment systems, a feature attributable to the porous pavement's ability to equalize flows entering or divert flows away from the sewerage system. This type of pavement installation can also offer a substantial benefit by recharging water supplies. Even more important are the safety features which could be realized, i.e., an increased coefficient of friction which will help prevent wet skidding or hydroplaning accidents, and enhanced visibility of pavement markings due to more rapid removal of rainwater and rougher surfaces. However, when porous pavement is considered, we must realize that such features as geographical area, temperature, subsurface soil condition, and the possibility of groundwater contamination may play an important part in design and site selection.

New Sewer Systems

New types of sewer systems being demonstrated, based on vacuum and pressure operation for the collection and conveyance of sanitary sewage, can reduce the waste volume generated, reduce conduit sizes, eliminate infiltration, minimize associated installation and treatment costs,

FIGURE 11

POROUS ASPHALTIC CONCRETE FEATURES



and alleviate overflows. More on this subject will be presented later by Mr. Carcich.

Treatment

Other than waste storage, it may be considered necessary that combined sewer overflows be treated, either at the individual outfall locations or at a centralized facility. Centralization, although offering benefits in reduced plant costs, invariably requires high expenditures for the installation of large, combined sewer transport conduits or interceptors.

Conventional treatment processes apply basically to the relatively steady-state conditions of sanitary sewage, whereas combined sewer overflows occur on an intermittent and random basis. Following rainfall, these flows exhibit highly-varying patterns in both quality and quantity over short periods of time. Consequently, it has been difficult to directly adapt existing treatment methods to storm generated overflows, especially the micro-organism dependent biological processes. Adverse flow conditions and unpredictable shock loadings make it advisable to consider the newer chemical and physical treatment techniques and the incorporation of automated control into the intended storm treatment facility to achieve optimum efficiency.

Rather than independent units, biological treatment systems are applied by our Program as auxiliary facilities at the conventional sewage plant for treating excess flows. This affords a viable mixed liquor and zoogloeal film. Two such biological treatment processes are on-going EPA projects. One uses activated sludge to treat overflows at Kenosha, Wisconsin. The other, at New Providence, New Jersey, utilizes plastic media and compares this with standard rock media in high-rate trickling filters for treating sanitary wastewater with a high degree of infiltration.

Treatment methods which have been evaluated or are currently under investigation by the Storm and Combined Sewer Pollution Control Program include:

1. Fine-mesh screening and microscreening
2. Dissolved-air flotation
3. Rotating biological contactors
4. High-rate plastic and rock media trickling filters
5. High-rate, single, dual and tri-media filtration
6. Swirl and helical separators
7. Advanced disinfection methods, e.g., high-rate application, on-site generation, automated operation, ozonation, and use of combined halogens (chlorine and iodine), and chlorine dioxide
8. Tube settlers
9. Powdered and granular activated carbon adsorption
10. Polymer and other chemical additives for improved settling, microscreening, filtration and flotation
11. Chemical oxidation
12. In-line or in-sewer treatment
13. Sludge handling and treatment
14. Regeneration of carbon and coagulants, and
15. Reclamation and reuse.

Time does not allow a detailed discussion of each of these methods Some of the more promising treatment techniques will be discussed.

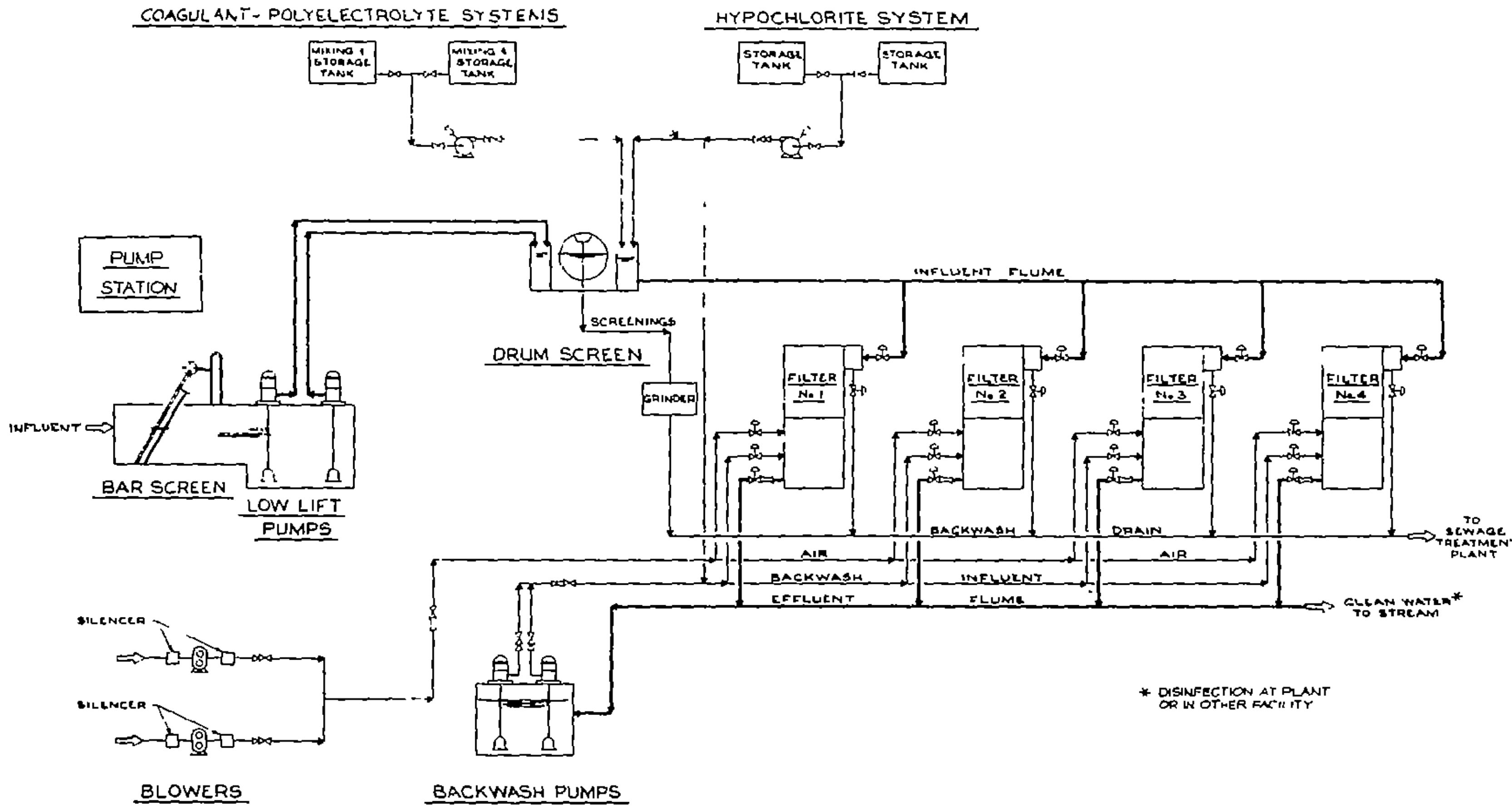
Since high throughput rates are necessary for combined sewer overflows, the sanitary treatment processes are being studied for possible modifications. For example, the microstrainer is conventionally designed for polishing secondary sewage plant effluent at an optimum rate of around 10 gallons per minute per square foot. Tests on a pilot microscreening unit in Philadelphia, Pa. have shown that, at high flux rates of 35 to 45 gpm/ft^2, suspended solids removals in combined overflows exceeding 99 percent can be achieved. Mr. George Glover will speak about this in more detail this afternoon.

Increased flow rates greatly reduce capital costs and space requirements. Increased throughputs have also been obtained with other fine-mesh screening processes, for example, fiberglass filtration and dissolved-air flotation.

An EPA study in Cleveland showed high potential for treating combined sewer overflows by contact coagulation and ultra high-rate filtration. Figure 12 depicts the process flow diagram. With the high loadings of 16 to 32 gpm/ft^2 surface area, removal of solids is effectively accomplished throughout the entire depth of filter column. Test work showed suspended solids removal up to and exceeding 90 percent and BOD removals in the range of 60 to 80 percent. Substantial reductions, in the order of 30 to 80 percent of phosphates, can also be obtained. Mr. Pat Harvey will discuss this at length later on today.

Results from a 5.0 MGD screening and dissolved-air flotation demonstration pilot plant, in Milwaukee, indicate that greater than 70 percent removals of BOD and suspended solids are possible. Findings also revealed 85 to 97 percent reduction in suspended solids, and better than 90 percent reduction in phosphate can be achieved as an additional benefit, by employing chemical coagulants. Mr. Gupta will give his presentation on this topic this afternoon.

A unique variation of the usual coagulation-adsorption, physical-chemical treatment process has been demonstrated in Albany. This



HIGH RATE FILTRATION INSTALLATION PROCESS FLOW DIAGRAM

FIGURE 12

system, shown schematically in Figure 13, is comprised of a 100,000 GPD trailer mounted pilot plant where both powdered carbon and coagulants are added in a static mixing-reaction pipeline, and the resultant coagulated matter is flocculated downstream, separated by tube-settlers and polished by multi-media filtration. The project also demonstrated regeneration of alum and activated carbon by fluidized-bed incineration.

At this point it is appropriate to bring out an important fact of which future designers of storm overflow treatment facilities must be cognizant--process efficiency should not be considered in the usual terms of percent removal used in municipal treatment. It was found during the microstrainer and dissolved-air flotation operation that, due to extreme variation of the influent suspended solids concentration, removal efficiency would also vary while the more desirable effluent concentration remained relatively constant. For example, a typical effluent concentration of 10 mg/l suspended solids would yield a reduction of 99 percent for an influent concentration of 1,000 mg/l, whereas the suspended solids reduction would be only 50 percent if the influent concentration were 20 mg/l. This phenomenon is apt to reoccur in other physical-chemical stormwater treatment operations.

Another project has studied a new biological process, described as the rotating biological contactor consisting of a series of shaft-mounted rotating disks. Similar in principle to trickling filtration, a biological growth attaches onto the disks. Under steady loading rates, efficiencies exceeding those of the trickling filter have been attained, but a surge tank appears essential. Figures 14 and 15 give a close-up of the rotating disks and an overall view of the pilot facility, respectively.

Another approach in overcoming the extreme variation in overflow rates is to provide surge facilities prior to the storm treatment plant or

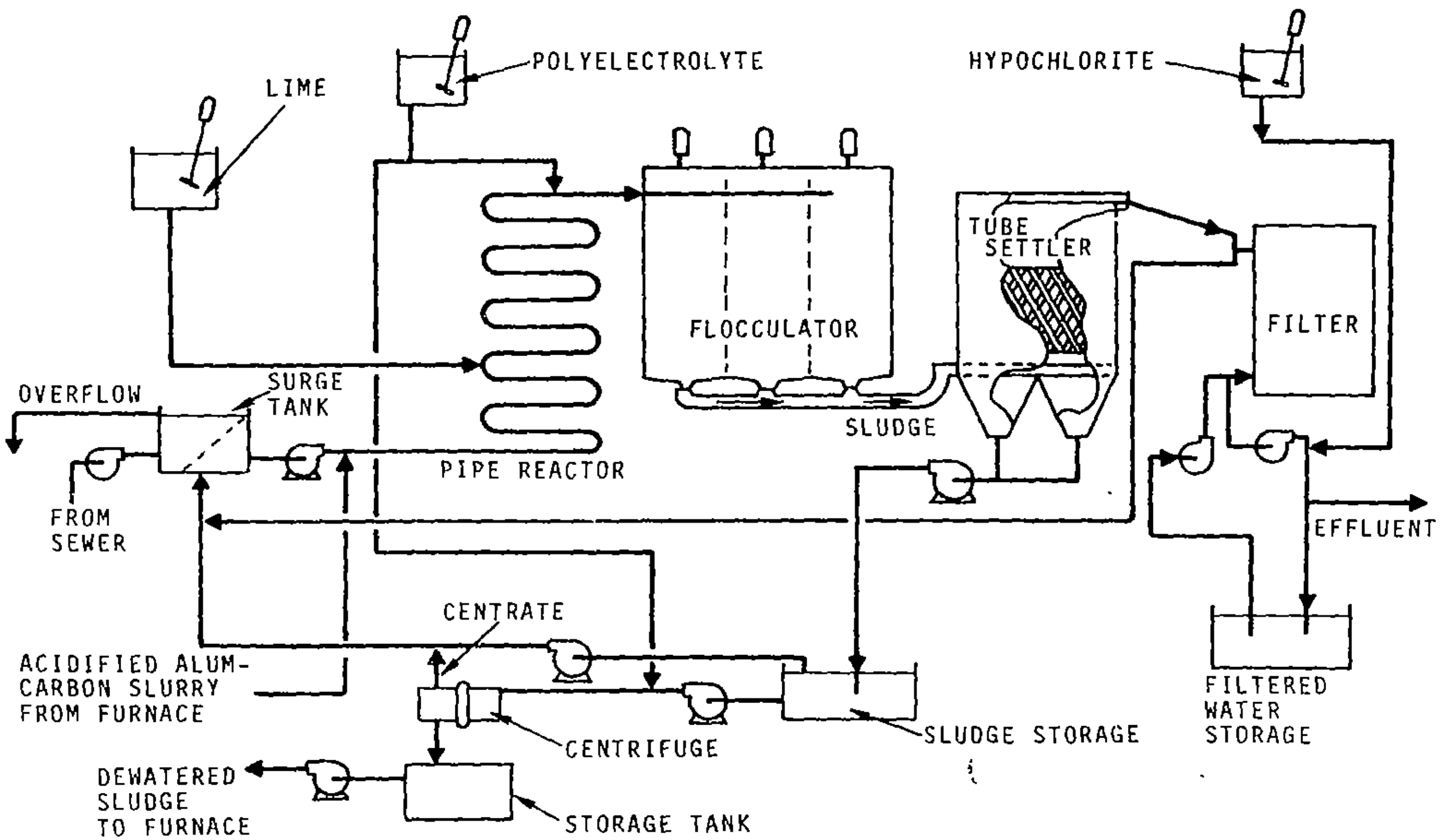


Figure 13. SCHEMATIC FLOWSHEET OF MOBILE PILOT PLANT

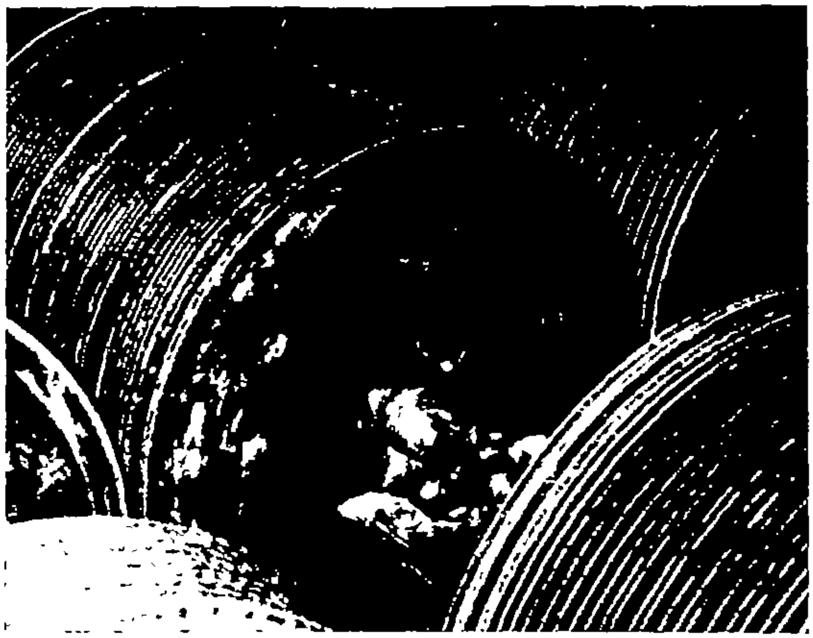


Figure 14. Close-up view of rotating biological disks, Milwaukee, Wisconsin.

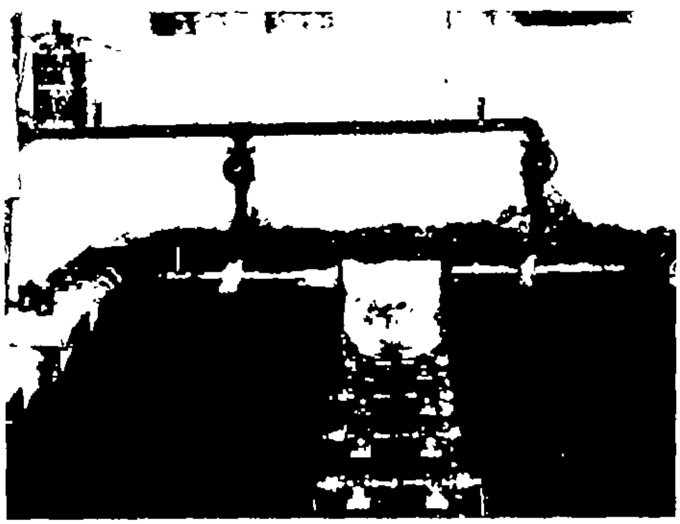


Figure 15. Overall view of rotating biological disks, Milwaukee, Wisconsin.

the municipal plant. The surge basin(s) (or existing combined sewers) could furthermore serve a dual function in equalizing not only wet-weather flows but dry-weather flows as well. In this way, a single future treatment system can readily be designed for storm and sanitary flow conditions. This could also assist presently overloaded sanitary plants in obtaining more uniform operation. Short-term storage incorporated into the treatment plant would even out the daily cycle of dry-weather flows allowing for more efficient use of the treatment process over the entire 24 hours. Equalization would permit reduced treatment process design capacity. Further analysis is necessary to determine the most economical break-even point between the amount of storage versus the treatment capacity. The designer should recognize the wet-weather treatment plant's capability to draft stored flow continuously while it is raining in his evaluation of the optimum surge-treatment system.

New Orleans has demonstrated the use of sodium hypochlorite for disinfection of storm flows as high as 11,000 cfs, to both reclaim and protect public bathing beaches. In order to economically provide the large quantities of disinfectant required, an on-site hypochlorite batching plant was constructed (Figure 16). Figure 17 gives a view of the massive-size chlorine contact basin in operation.

The disinfection of combined sewage entails certain differences, which make the design and operation of facilities difficult when compared to sanitary sewage. The highly varying qualitative and quantitative character of the storm generated inflows require disinfectant dosages to be based on a predicted rather than an established technique. A decrease in temperature decreases disinfectant kill power. This points to the importance of temperature in additon to the usual (time and dosage) control parameters. As temperature is apt to have a much wider range for runoff waters than it does for domestic sewage flows, combined sewage may require disinfectant dosage to vary season-

Figure 16. Stormwater disinfection project - hypochlorite batching plant, New Orleans, Louisiana.

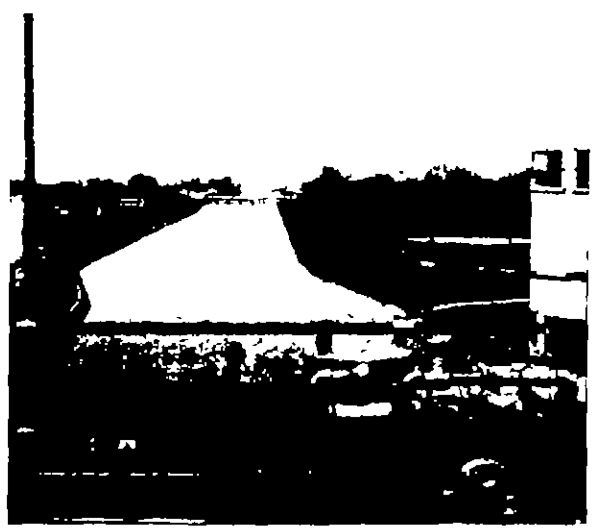


Figure 17. Stormwater disinfection project - chlorine contact basin, New Orleans, Louisiana.

ally or as effected by ambient temperature.

The Storm and Combined Sewer Overflow Technology Program is also searching for high-rate disinfection systems to save on large tankage requirements for the high storm flow rates encountered, with the help of more rapid oxidants e.g. chlorine-dioxide, and by imparting greater turbulence to the flow. Successful attempts toward high-rate disinfection are being noticed at our Philadelphia, Pa. and Onondaga County, New York demonstration sites. The Philadelphia project also made an evaluation of ozone, generated on-site for disinfection purposes. Another study proposes the use of combined halogens (chlorine and iodine) to provide more effective disinfection of viruses as well as baeteria in a swimming lake. This study also supports dechlorination by activated carbon or use of ozone, with a relatively short half life, in lieu of chlorine to alleviate residual toxicity problems to fish life. Mr. George Glover will present more on this subject.

Combinations

When a single method is not likely to produce the best possible answers to a given pollution situation, various treatment and control measures--as previously described--may be combined for maximum flexibility and efficiency. One such combination might be: in-sewer or off-system storage for subsequent overflow treatment in specifically designed facilities, followed by groundwater recharge or recovery for water sports and aesthetic purposes. Another combination might be flow retention with pump or gravity feed-back to the sanitary sewerage system.

In all cases the optimum abatement plan for stormwater overflow pollution will have to be evaluated separately for the geographical area in consideration. Aside from climatological conditions, terrain, and land uses, choice of control and treatment will depend on the existing sewerage system configuration. For example, systems with large contributory areas and few overflow points present problems and require design philosophies which differ from those in systems divided into many subdrainage areas with individual combined wastewater outfalls.

The temporary storage concept, previously discussed as a control process, also provides for a certain degree of treatment by settling, for excessive overflows greater than the design storage capacity discharging directly to the receiving stream. Likewise, this settling potential for flows less than design capacity, together with on-site solids disposal usually overlooked, should be definitely considered. The proposed prototype demonstration for Lancaster, Pennsylvania, previously cited and shown schematically in Figure 18, will pre-treat by a swirl device and microstrain and disinfect discharges greater than the storage capacity of the "silo" structure.

Mr. Clemens, Michigan installed a system involving discharge of combined sewage overflows into a series of three "lakelets" each equipped with surface aerators. Effluents pass from one pond to the next through microstrainers and filters, and the final effluent is chlorinated. This control and treatment scheme is designed to have no adverse aesthetic impacts, and the possibility of reusing these waters for recreational purposes is being explored. Figure 19 shows a schematic of the Mt. Clemens facility.

A conceptual engineering study for the Washington, D. C. area (Figure 20) has shown that it would be feasible to construct a control-treatment facility to handle combined sewer overflows up to 3,000 cfs. A 175 million gallon storage facility is tentatively planned with an overhead parking garage, coupled with a 50 MGD high rate filtration-adsorption-disinfection plant. This treatment complex is intended to produce reclaimed waters suitable for swimming, boating, and fishing.